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The Mechanical Behaviors of Epoxy Polymer Composite

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ABSTRACT: *Composite material is commonly used in most industries. It became a basic substance in many Industries air craft, automobile and boats. Therefore many researches and test have been made by taking samples and making tensile, fatigue test as well as to know the rang bear of epoxy polymer to loads subjected it. The research explain about identification introduction of epoxy polymer and its uses and properties as well as problems withstand in manufacturing and production, also the research include conclusion of previous researches in the same filed, the theories and the equation which are used to know how made the specimen, and what are condition must be known in design that's effect on the mechanical properties for epoxy polymer, as well as the experimental filed consists is tensile and fatigue test that has been made.*

I. Introduction

Classification of composite materials of the structural types. The definition for advanced composite material a Structural classification according to the use off the following. Typical constituent is tabulated below or the Macro structural type is the most important for further dissection here in continuing with this next consider a combination of A materials is a described and shown in table (1)

Table (1) Classification of composite materials [1]

STRUCTURAL LEVELS	
(1) Single molecules, crystal cells	Basic / elemental
(2) Crystals, Phases, compounds	Micro structural
(3) Matrices, fibers, particles	Macro structural

The structural types cited above, type III or the macro structural type is the most important. The manufacturing process for glass fibers suitable for reinforcement uses large furnaces to gradually melt the sand/chemical mix to liquid form, then it is extruded through bundles of very small orifices (typically 17-25 micro meters in diameter for E-Glass, 9 micro meters for S-Glass).these filaments are then sized with a chemical solution. The individual filaments are now bundled together in large numbers to provide a roving. The diameter of the filaments, as well as the number of filaments in the roving determine its *weight*. This is typically expressed in yield-yards per pound (how many yards of fiber in one pound of material, thus a smaller number means a heavier roving, example of standard yields are 225yield, 450yield, 675yield) or in tax-grams per km (how many grams 1 km of roving weighs, this is inverted from yield, thus a smaller number means a lighter roving, examples of standard tax are 750tax, 1100tax, 2200tax).

These roving's are then either used directly in a composite application such as pultrusion, filament winding (pipe), gun roving (automated gun chops the glass into short lengths and drops it into a jet of resin, projected onto the surface of a mold), or used in an intermediary step, to manufacture fabrics such as *chopped strand mat* (CSM) (made of randomly oriented small cut lengths of fiber all bonded together), woven fabrics, knit fabrics or uni-directional fabric Sizing A sort of coating, or primer, is used which both helps protect the glass filaments for processing/manipulation as well as ensure proper bonding to the resin matrix, thus allowing for transfer of shear loads from the glass fibers to the thermoset plastic. Without this bonding, the fibers can 'slip' in the matrix and localized failure would ends.

II. Literature Survey

The fiber can be short or long the long fiber are easy to orient And presses and many benefits over short fiber these include Impact resistance, low shrinkage, improve surface finish and Dimensional stability , but short fiber provide low cost ,are easy to work with, and have fast cycle time fabrication procedure and have higher strength [1]. The most common shape of the fiber is circular because Handling and manufacturing them is easy. Hexagon and Square shape fiber are possible, but their advantage of strength And high packing factors don't out weight the difficulty in Handling and processing [2]. The material of the fiber directly influences the mechanical behavior of the composite fiber are generally expected to have High elastic moduli and strength this expectation and cost have Been Kay factor in the glass dominating the fiber market for Composite [3]. Fiber oriented in one direction give very high stiffness and Strength in that direction if the fiber oriented in more than one Direction, such as in a mat there will high stiffness and strength In the direction of the fiber oriented [4]. The matrix factor Is formed between the fiber surface and the matrix some Fibers bond naturally to the matrix and other don't. coupling Agent are compounds applied to fiber surface to improve the Bond between the fiber and matrix [5]. The matrix higher than that of the fiber, and the manufacturing Temperature are higher than the operating temperature the matrix will radically shrinkage more than the fiber. This causes the matrix to compress around the fiber [6] .Temperature is the most important of environmental factors affecting the behavior of composite materials. First, because polymeric composites are rather sensitive to temperature and have relatively low thermal conductivity, this combination of properties allows us, on one hand, to use these materials in structures subjected to short-term heating, and on the other hand, requires us to perform analysis of these structures with due regard to temperature effects. Second, there exist composite materials, e.g., carbon-carbon and ceramic composites, that are specifically developed for the operation under intense heating and materials like mineral-fiber composites that are used to form heat proof layers and coatings. And third, fabrication of composite structures is usually accompanied with more or less intensive heating (e.g., for curing or carbonization), and the further cooling induces thermal stresses and strains to calculate the needing of the attract equations of thermal conductivity and thermoelsticity [7]. The initial high modulus of the fabric is probably due to frictional resistance to bending of the thread. Once the frictional restraint is overcome, a relatively low modulus is obtained which is mainly governed by the force needed to unbend the threads in the direction in which the force is being applied, and, at the same time, the need to increase the curvature in the threads at right angles to the direction of application of the force.

III. Theoretical

It is necessary to appreciate the geometrical changes that take place during the extension. In general, the changes should allow for extension of the yarn and for the compression of the yarn in the intersection region, but for the case where such geometrical changes are most important, the forces are relatively low and it is useful, therefore, to consider the geometrical changes that take place under the restricted condition that the compression of the yarns and their extension can be considered to be negligible [8].

The basic equations involved are those connecting the height of the crimp wave, h, the crimp, c, the yarn spacing, p, and the yarn length, I. These equations are:

$$h/p = 4/3\sqrt{c}$$

$$l = (1+c)p$$

The assumptions made are that 1 is constant and that the sum of h for warp and weft sections is constant. (This is a result of the assumption that the yarns are not compressed.) Hence we have:

$$0 = d\,(h_1 + h_2) = 4/3\sqrt{c_1}\,dp_1 + 2/3\frac{p_1}{\sqrt{c_1}}\,dc_1$$

$$+ 4/3\sqrt{c_2}\,dp_2 + 2/3\frac{p_2}{\sqrt{c_2}}\,dc_2$$

$$dc = -(1+c)dp/p$$

$$\frac{dp_2}{dp_1} = \frac{1-c_1}{1-c_2}\frac{\sqrt{c_2}}{\sqrt{c_1}} \qquad . \qquad (1)$$

This equation gives the Poisson's ratio for the cloth under all conditions where it can be assumed that the yarn extension and the compression of the yarns is negligible.

By using the above equations it can be shown that:

$$\frac{dh}{dp} = \frac{c-1}{1.5\sqrt{c}} \tag{2}$$

These equations make it possible to consider the modulus for several possible variations in the loading of a cloth. If the loads in the warp and weft directions are f_1 and f_2, the number of warp and weft yarns in the cloth are n1and n2, respectively, then it follows, if the internal energy changes are negligible, that:

$$f_1 n_2\, dp_1 = -f_2 n_1\, dp_2$$

since the warp and weft extensions are n2 dpi and n1 dp2, respectively.
Hence

$$\frac{F_1}{F_2} = \left(\frac{1-c_1}{1-c_2}\right)\frac{\sqrt{c_2}}{\sqrt{c_1}} \simeq \frac{\tan\theta_2}{\tan\theta_1}$$

Where F = f/n, the force per yarn. The approximate relationship is exact if one uses Peirce's model (Peirce, 1928) since, in this model, the threads at the center line of the cloth are straight and it becomes obvious that:

$$F_2 \tan\theta_2 = F_1 \tan\theta_1$$

The small difference between the modulus obtained by the above approach and the direct method based on Peirce's geometrical model is due to the different geometrical assumptions made. In this particular case the Peirce approach is simpler but it is not suitable for some cases, it has not been used in general.
The modulus for the increase in F1 when F2 is constant can be obtained small for changes in the extension by suing the above equations .

$$\frac{F_1}{F_2} \simeq \frac{\sqrt{c_2}}{\sqrt{c_1}}$$

Hence:

$$(dF_1)_{F_2\,const.} = F_2\left({}^1\!/_2\,(c_1 - c_2)\right) - \left({}^1\!/_2\left({c_1}^{1/2} - {c_2}^{1/2}\right) dc_1\right)$$

The modulus of the cloth can be defined as the change in the force per unit width of cloth per fractional increase in length, i.e. dF/p2divided by dp,/pi: Hence

$$\text{the modulus } = \frac{p_1}{p_2}\left(\frac{dF_1}{dp_1}\right)$$

which by rearrangement of terms, and using the known connection between c and p becomes:

$$\frac{F_2}{2c_1 p_2} = \left[(1+\ c_1)(p_1/p_2) + (1+\ c_1)(c_2/c_1)^{1/2}\right] \tag{3}$$

IV. Experimental Work

There is a slight difference in technique when using Epoxy Polymer Composite and fiberglass mat such as that used in boats, shower stalls, and other projects.

4-1 Manufacturing process

The instructions provided in the well-written Cozy plans assume that the builder understands how to perform this task by this point and summarizes the step in four sentences with an illustration included.

Step 1 prepare the work piece

The first step is to fully prep the area about to receive the layup by sanding the area and then cleaning the resultant residue. For this kind of prep work, using a palm sander (Porter Cable) with a fairly coarse sheet of paper(36 grit) followed by hand sanding with a sheet of sandpaper wrapped around a soft spongy sanding block. For many layups, a power tool simply will not fit in the area being worked on, sanding an area significantly larger than the area of the layup. After sanding, wipe and dust clean with a towel and/or vacuum using a shop vac. Many recommend that shop-air should not be used for cleaning and dusting because it could contain a mist of oil. If the layup does not have clear landmarks about where it should be placed, place markers in ink on the

work piece. In this case, a 12 inch long layup will be placed onto the structure. This layup involves an inside curve with 8 inches of the layup on the fuselage sides and 4 inches onto the F22 bulkhead at the double area we have placed small red ink marks just outside 8 inch mark and 4 inch mark, the layup will be between the two red marks .

Step 2.Prepare the fiberglass cloth

The plans generally specify to layup layers of glass on wax paper, doing many layups using wax paper. However starting with a piece of white bead foam type Styrofoam that is sold at any hardware store as insulation material. A plywood surface with reasonable smoothness would also work just fine. Then roll out enough "heavy duty aluminum foil" upon which to draw out the size of the glass layup work with the dull side up, using Sharpie markers (type of wide marker) to accurately mark out the final size that the layup should be.

Step 3. Wet out the fiberglass

Before wetting out the cloth, it is important to prepare the area with the necessary materials before getting started. Below, preparing mixing sticks, epoxy cups, squeegees (rubber and hard plastic), a grooved roller (many builders using this technique use a roller), brushes, credit cards or other plastic cards (the best squeegees around), Dritz electric scissors (mine is covered in green plastic and masking tape to protect it from epoxy), and protective nitrile gloves. Then the epoxy start to harden or thicken before the layup done.

Step 4. Apply to the work piece.

Paint clean / raw mixed epoxy onto the work piece in an area slightly larger than the layup. With the 4-mil plastic peeled away and disposed, apply the epoxy-preimpregnated glass cloth into the proper place with the aluminum foil backing still in place. Squeegeeing gently through the aluminum foil to ensure a good bond to the work piece. Press the layup into any corners or contours well while the aluminum foil is on the layup.
Peel away the all of the aluminum foil carefully, check for bubbles, and add epoxy using a disposable brush to any dry areas. The foil should come off without causing a disruption in the glass cloth. *Stipple* (gentle repeating stabbing motion with a brush) any dry areas or bubble areas to distribute epoxy. Holding the credit card or finger into any corners will help avoid bubbles in that area as the foil is gently pulled off. Squeegee further through the peel ply until the peel ply is wet and bubble-free. Use the peel ply to make sure that the corners are well attached to the work piece, the final product looks bubble free, and that the layup looks good. Allow to cure in a warm environment (75 degrees for higher ideally), and remove peel ply after full cure.

The final product, is bubble-free, well textured due to the peel-ply, ready for an additional layup, and has a smooth transition between new glass and old glass. In this case, there is some overhang toward the lower right of the photo. This hard cured fiberglass overhang can be cut away with the Fein tool and then sanded smooth by hand or with a Dremel style rotary tool. Figure (1) shows the configuration and dimensions of fatigue specimens (Din) were machined from 2.l mm thick rolled plates with length direction of specimens parallel to longitudinal rolling direction [9]. The final machining is the fine grinding and the surface roughness of machined specirnens is Ra (average roughness) 0.7-1.3 µm.

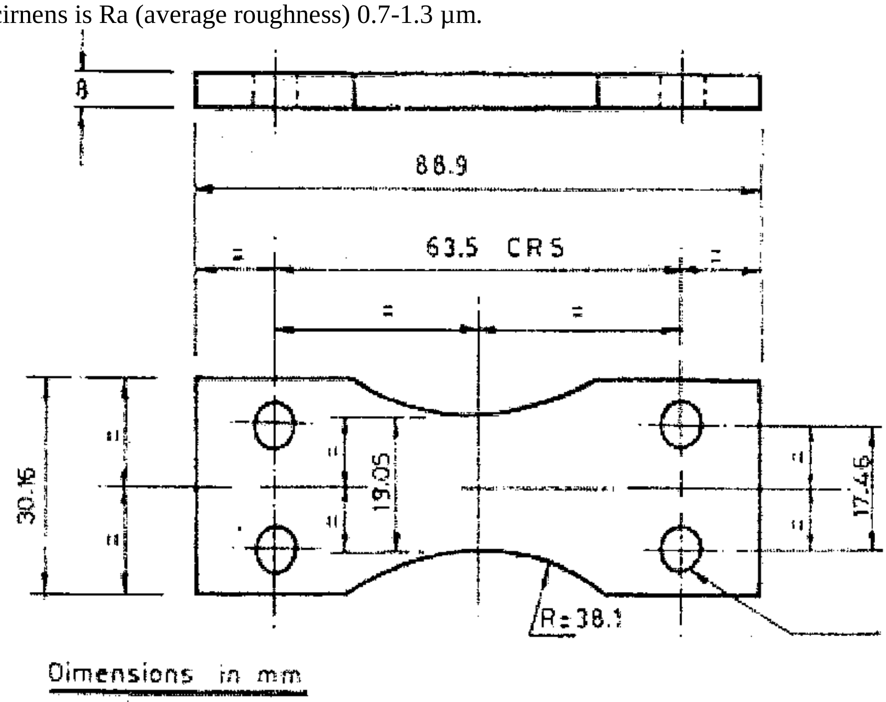


Figure (1) the dimensions of Fatigue specimen [9]

Fatigue tests were carried out on reversed-bending machine (Avery Denison LTD) With frequency of 5 HZ at room temperature and stress ratio R:-1.

Table 2 Mechanical properties of fatigue specimens

Property	Tensile Strength		Yield Strength		Ductility percent	Endurance limit	Modulus of elasticity
	(KSi)	(Mpa)	(KSi)	(Mpa)		(Mpa)	(Gpa)
Standard	98	679	91	627	9	152	73
Experimental	94	649	88	606	10	111	70

V. Discussion And Results

In materials science, fatigue is the progressive and localized structural damage that occurs when a material is subjected to cyclic loading. The nominal maximum stress values are less than the ultimate tensile stress limit, and may be below the yield stress limit of the material .Using the fatigue test .to know the maximum bear of the fiber glass to the load subjected for it and the result from the testing show that the number of cycle to failure when decrease that stress subjected is increasing and the purpose from it "safely".

In high-cycle fatigue situations, materials performance is commonly characterized by an *S-N curve*,. Figure 2 is a graph of the magnitude of a cyclic stress (*S*) against the logarithmic scale of No. of cycles to failure (*N*). S-N curves are derived from tests on samples of the material to be characterized where a regular sinusoidal stress is applied by a testing machine (the stress values as in table(3). Which also counts the number of cycles to failure.

Table (3) the value of stresses applied

Stress.10^6 Nlm^2	No of cycle to failure
130	4.6
120	5.5
105	5.9
95	6.06

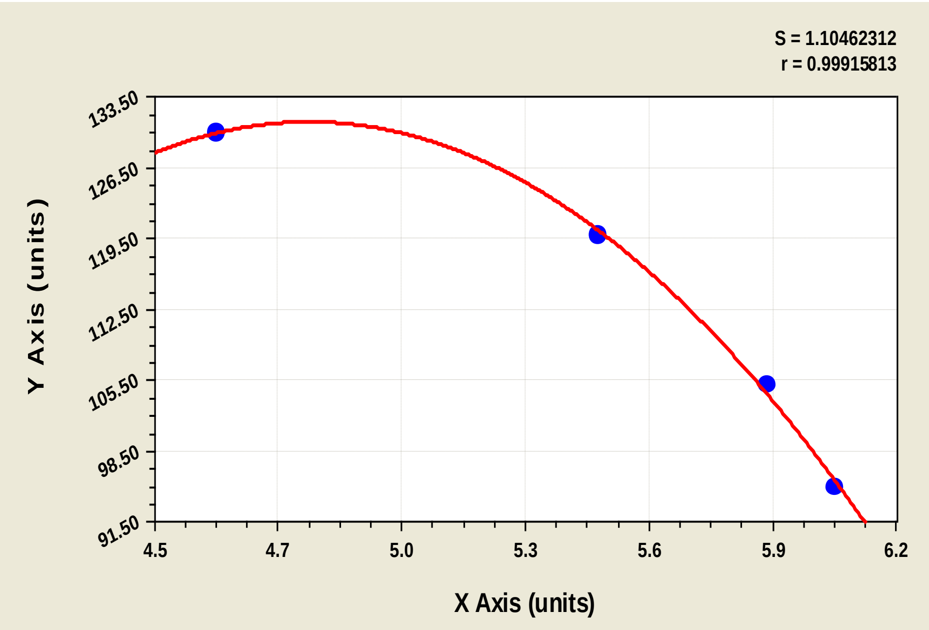


Figure 2 experimental S-N curve

This process is sometimes known as coupon testing [8]. Each coupon test generates a point on the plot though in some cases there is a run out where the time to failure exceeds that available for the test. Analysis of fatigue data requires techniques from statistics, especially survival analysis and linear regression.

Use_ Defined Model : Y=A N^b

The theoretical and experimental resultants are equal.

According to theoretical resultants:

$y = 130$ MPa

and experimental resultants:

$y = 130.03$ MPa

during tensile testing of a material sample figure (3), the stress–strain curve is a graphical representation of the relationship between stress, derived from measuring the load applied on the sample, and strain, derived from measuring the deformation of the sample, i.e. elongation, compression, or distortion.

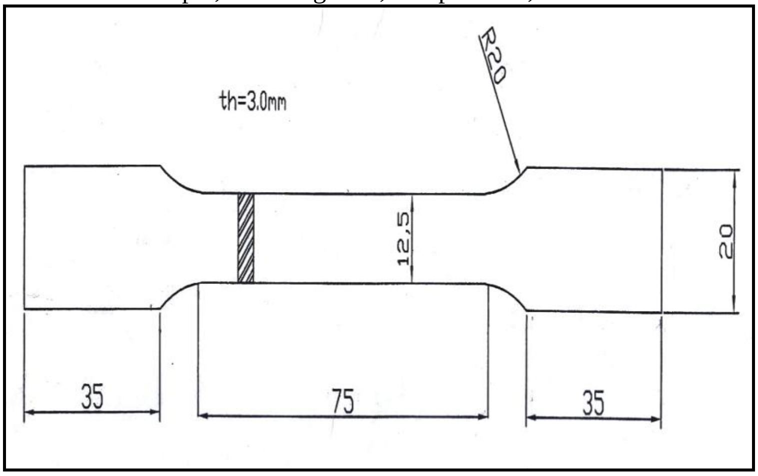


Figure (3) Show the dimension of tensile specimens Din50120

The slope of stress-strain curves for experimental work (figures 4,5,6,7 and 8) at any point is called the tangent modulus; the slope of the elastic (linear) portion of the curve is a property used to characterize materials and is known as the Young's modulus. The area under the elastic portion of the curve is known as the modulus of resilience.

The nature of the curve varies from material to material.

The following diagrams illustrate the stress–strain behavior of typical materials in terms of the engineering stress and engineering strain where the stress and strain are calculated based on the original dimensions of the samples. (see the information inside the figures) .

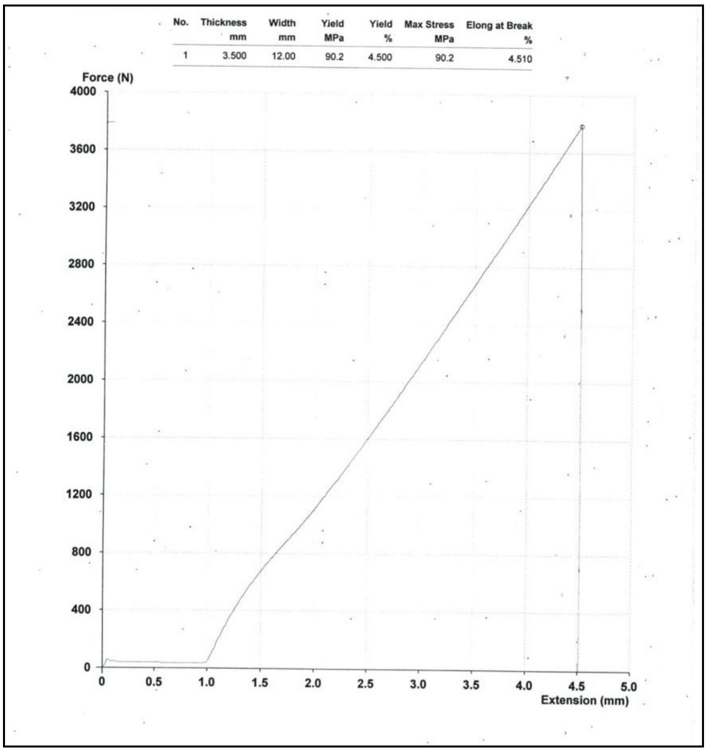
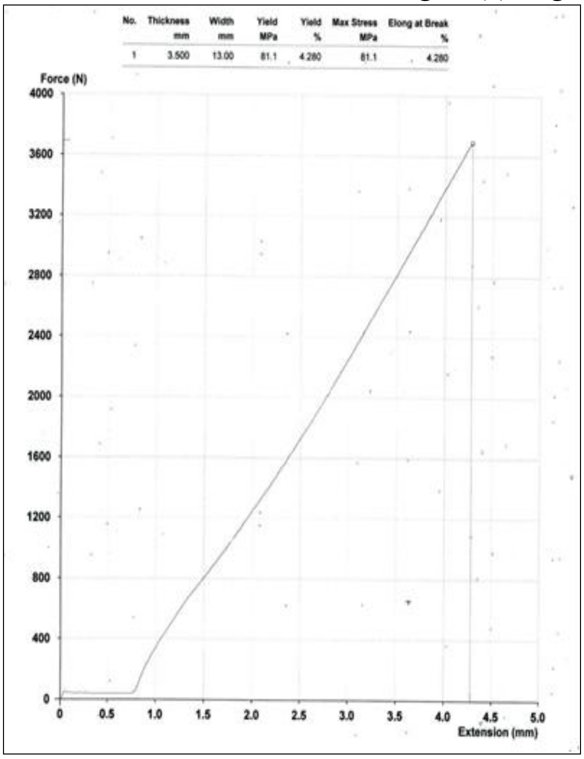


Figure (4) diagram: spec*im*en No.1



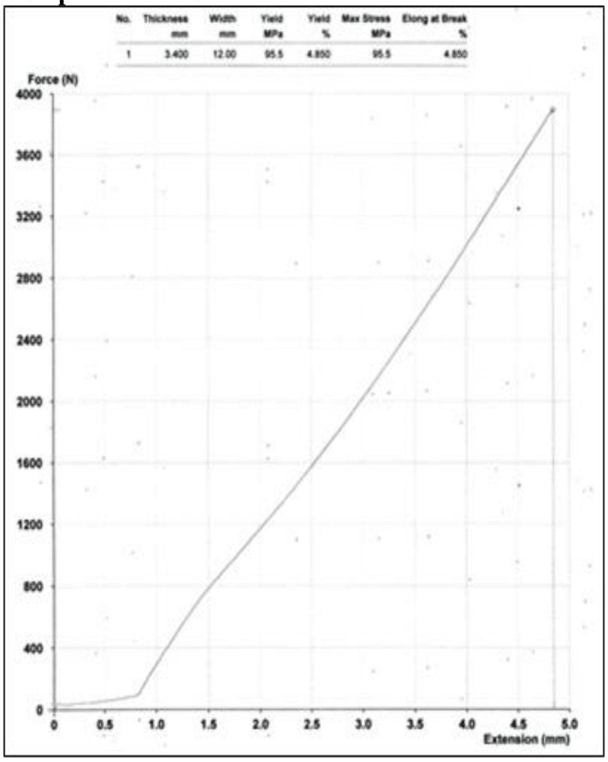
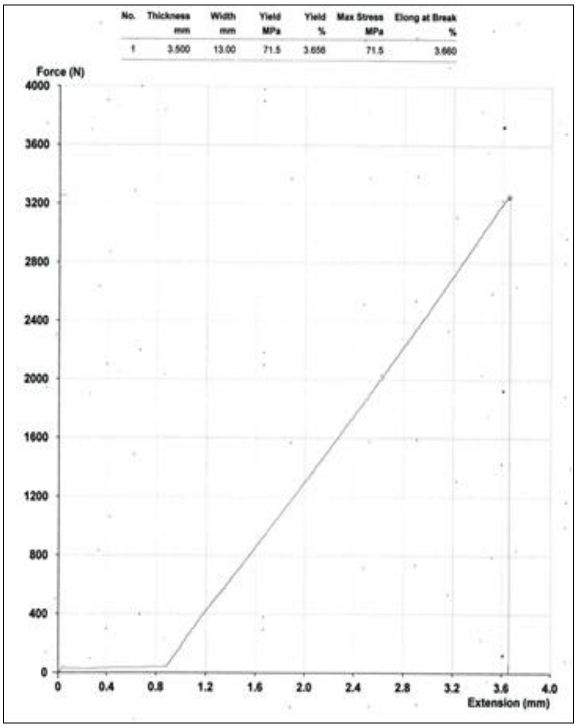


Figure (5) diagram: specimen No2

Figure (6) diagram: specimen No.3



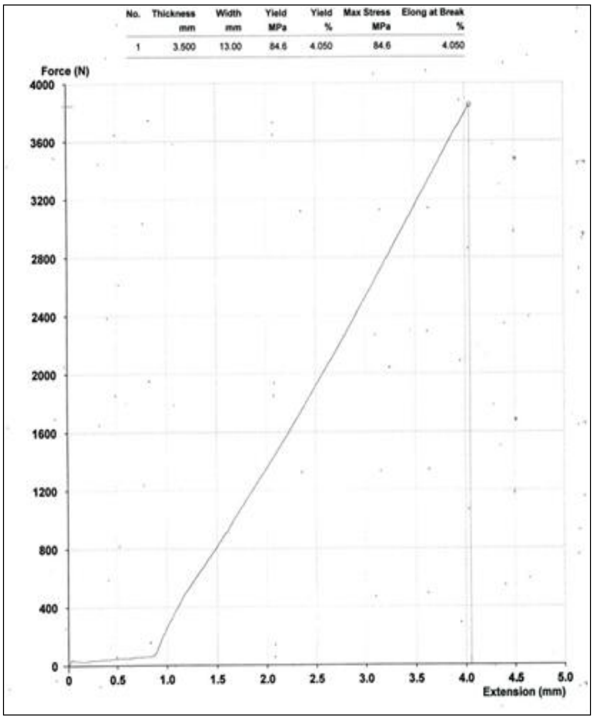


Figure (7) diagram: specimen No.4

Figure (8) diagram: specimen No.5

From the above curves we noted that the modules of elasticity values present in each point on the curves are changing from point to point.

VI. Conclusion

1-Using (Epoxy Polymer composite) preparation to impregnation to produce Lamina after that Lay- up and consolidation to ensure removal the air and gas from layer, eventually solidification after that making specimen.
2- Studying the mechanical behavior of (Epoxy Polymer composite) by using fatigue and tensile test. definite the maximum bear for fiber glass tension and fatigue load when subjected it.
3- Analysis of fatigue data requires techniques from statistics, especially survival analysis and linear regression.

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